TREASURY DEPARTMENT

UNITED STATES PUBLIC HEALTH SERVICE

HUGH S. CUMMING, SURGEON GENERAL

MALARIA

LESSONS ON ITS CAUSE AND PREVENTION FOR USE IN SCHOOLS

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INTRODUCTION

Teaching some of the facts about malaria in schools is not new. It was done in San Antonio in 1904 after the yellow-fever outbreak of 1903, when the writer first had cognizance of it. There are chapters on malaria and mosquitoes in most of the textbooks on hygiene used in the public schools.

This pamphlet is, however, intended to be rather more complete than the chapters devoted to malaria in the textbooks mentioned, as the importance of the disease seems to demand. Without question, in some parts of the United States where malaria is prevalent it is more important and does more injury than all other diseases combined, and measures for its control should be emphasized. As the campaign for the control of malaria is likely to be a long one, it seems very advisable so to educate the rising generation that they may bear their full part in it. Knowledge of malaria, how it is conveyed, and how it may be controlled, if generally spread among all the people, will ultimately compel the control of malaria.

The manuscript of this article was submitted to Surgeon von Ezdorf, Public Health Service, and has received the benefit of his suggestions, many of which have been adopted.[1]

I wish also to acknowledge my indebtedness to my secretary, Miss Laura A. Carter, who was really a collaborator in this work, and to Miss Ethel Neely, secretary of the Virginia Society for the Study and Prevention of Malaria, who kindly allowed me to examine a course of excellent lessons for schools prepared by herself. The arrangement of her course of lessons—questions and answers—is followed in this paper as being better for school use than a connected narrative with the questions subjoined.

These lessons, or rather this catechism on malaria, are presented then for use in schools, especially those in the country, either as they are written or as a basis for lessons more suitable for the different needs of the schools in different sections.

To the Teacher

It was at first intended to make these lessons for children only and, consequently, very simple; to make them *true*, however, required either to make them less simple or to trust to the teacher to

[1] Some revision has been made in this edition by J. A. Le Prince, senior sanitary engineer, and T. H. D. Griffitts, epidemiologist, U. S. Public Health Service.—Ed.

explain difficulties and answer questions that would naturally arise. Now it may be that some of the teachers will not have sufficient knowledge of the subject to answer the questions which will be asked and give the necessary explanation—for accurate knowledge on even the rudiments of this subject is not so common—and on this account this little paper is intended for both pupils and teachers. The questions marked (a) are intended only for the pupils. The others (b) are for the teacher and deal with ideas a little more complex than the others, yet not especially so. They contain facts, however, which a teacher must know to understand the subject at all. Some are marked (a) ? as the writer was unable to decide whether they should be marked (a) or (b).

Teachers, however, will use their own discretion in giving to pupils such of the questions intended for themselves as the age and intelligence of the class may justify.

Each school should form a field class among the pupils studying malaria to find the larvæ of the different kinds of mosquitoes and to identify them and to learn to recognize the different kinds of places in which they breed; where the larvæ of the different families of mosquitoes may be found and identified.

Larvæ of *Culex* mosquitoes may be found in almost any standing water, especially in rain barrels, in pools and puddles almost anywhere; *Aëdes* (*Stegomyia*) *aegypti* in artificial containers about houses. *Anopheles* larvæ will be found in the pools described. The first two can be seen at once and recognized as not being *Anopheles* by their position, hanging head downwards. If one leans over a pool containing *Anopheles* and waits a little he will be able to see these larvæ lying flat at the surface of the water. He must wait a little, however, as they are likely to dive when one approaches them; also they frequently wiggle to the edge and hide in the grass, so they are sometimes not so easy to see even when present. The best way to get them is with a dipper. *Dipping* in the water, unless you see larvæ, is not the best way; make a quick stroke, just skimming the water towards the edges of the pool. Carry it into the grass or floatage, because the larvæ seek such protection. Do not make this stroke until you have given the larvæ time enough, after you arrived, to dive and come to the top. Another way is to press the edge of the dipper suddenly under water, so that the stream of water running into it may wash the larvæ into the dipper. Pour the contents of the dipper into a white bowl and you will see the larvæ against the white ground. The young *Anopheles* are light gray, banded with black, and very slender. The older ones are red, green, black, etc., the color depending on what they eat. All are quick in movement, and although they will dive, yet they also dart along the sur-

face of the water, which the others never do. Some are extremely small.

The eggs of *Culex* are easily recognized, being brown rafts half as long as the nail of one's little finger or less. (See fig. 10.) The eggs are set on end in the mass. They are common on water barrels. *Anopheles'* eggs are in loose groups (see fig. 11), the eggs lying flat on the water singly. They are very much harder to find and require a hand magnifying glass. They are usually demonstrated by keeping female *Anopheles* mosquitoes (that have fed) in a jar with water at the bottom, on the surface of which they will deposit their eggs. Eggs may occasionally, but very rarely, be found in nature on the surface of water containing many very young larvæ. Dip this water up in a saucer and examine with a hand glass.

Keep them in a vessel with a wide mouth—fruit jar, candy jar, etc.—half full of water or less, with pieces of grass in it extending above the water. Cover it with mosquito netting and some of the larvæ will develop into mosquitoes, and you can tell the kind. The larvæ are cannibals, and the big ones eat the others. *Anopheles* are much harder to raise than *Culex*, and unless one starts with nearly full-grown *Anopheles* larvæ or pupæ it is difficult to develop the mosquitoes from them unless one takes a pan or trough and makes enough of a marsh to imitate natural conditions. Some of the points of difference of mosquitoes and larvæ can be seen with the naked eye, but a good hand lens is of great assistance and makes the study much more attractive.

The pupils should be encouraged to do such antimalarial work as is practicable for them. That directed against mosquitoes is the most practical; compositions on subjects connected with the lessons; verbal reports—say, weekly—during the malarial season of what each one has done in the way of antimalarial work will increase the interest in this subject. The fuller the knowledge the teacher has of the subject and the more it is explained and developed, the more the pupil will be interested and will profit.

MALARIA

SECTION I.—MALARIAL FEVER AND ITS CAUSE

(a) Q. *What is malarial fever?*

A. A disease of man, common in hot, wet countries.

(a) Q. *What is malarial fever sometimes called?*

A. Chills and fever, bilious fever, swamp fever.

(a) Q. *Is this disease found in the United States?*

A. Yes. In certain areas along the coastal plain from Connecticut to Texas, over nearly all of the lower Mississippi Valley, and in a number of valleys on the Pacific coast.

(a) Q. *What causes malarial fever?*

A. The presence of certain small organisms in the blood of the person who has the fever.

(a) Q. *What do you mean by an "organism"?*

A. Something that is alive and thus has the power to reproduce its kind. It may be alive as a plant is alive, or alive as an animal is.

(a) Q. *Is the organism which causes malarial fever a plant or an animal?*

A. It is an animal, and in the blood is said to be an animal parasite.

(a) Q. *What do you mean by a "parasite"?*

A. An animal or plant that lives at the expense of another, like the mistletoe, love vine, rust on corn, or the hookworm, flea, etc. The malarial parasite lives in man only by feeding on the blood cells of the man.

(a) Q. *How do you know that these parasites are found in the blood of those who have malarial fever?*

A. Because with the microscope we can see them in the red blood cells of a person sick with malarial fever.

(a) Q. *What do you mean by red blood cells?*

A. They are very small bodies floating in the blood, shaped much like a biscuit, with thickened edges; they give the blood its red color, and are a most important part of it. They are essential to life.

How Malarial Fever Is Taken

(a) Q. *How do these malarial parasites get into the blood?*

A. In one way only: Through the bite of a mosquito. Malaria is not acquired by eating improper food, by drinking bad water, by

bathing in the sun, or in any other way than by the bite of a mosquito. True if one already *has* malaria, that is, *has these parasites already in his blood*, doing these things will develop it—"bring it out"—so that he may have a malarial attack which he could otherwise escape, but only if he is *already* infected with malaria.[2]

(a) Q. *Do all kinds of mosquitoes transmit malarial parasites to a person?*

A. No. Only *Anopheles* mosquitoes carry malaria, and only some kinds of *Anopheles*.[3]

(a) Q. *Are mosquitoes born with this power of conveying malaria?*

A. No. They acquire it only by biting a person who has these parasites in his blood. The parasites are taken then from a person by a mosquito and go back from the mosquito to another person. Where the parasites first started we do not know.

(a) ? Q. *How, then, does malaria spread?*

A. Like yellow fever. A female mosquito of a certain kind feeds on a person infected with malaria and sucks up blood with malarial parasites in it. She can not convey malaria to those whom she bites for some days (a week or more) after this, but after waiting a while (the reason for which will be told later) she injects these parasites into other persons whom she bites and infects them with malarial fever.

(a) Q. *What, then, is necessary to spread malarial fever?*

A. *Anopheles* mosquitoes, malarial parasites, and healthy persons. The parasites may be either already in the infected mosquitoes or in infected persons, from whom the mosquitoes can get them by biting.

How to Tell Malarial Mosquitoes

(a) Q. *Do both male and female mosquitoes bite?*

A. No. The female bites; the male does not bite.

(a) Q. *Can you describe the head of a mosquito?*

A. All mosquitoes have a bill and two *palpi* (*pal-pee*), which lie close to it, one on each side. Outside the palpi are two *antennæ* (*an-ten-nay*) which spread apart. The antennæ of the male are plumelike; those of the female are not. (See fig. 2.)

Q. *How, then, can you tell the male from the female?*

A. The male has "plumes on his head."

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[2] The teacher should here tell the class of the conveyance of malaria to Dr. Patrick Manson, jr., in London, by mosquitoes infected in Italy and brought thence to London; of the experiments of Sambon and Low at Ostia, living all summer in a screened house and keeping well, although drinking the same water and eating the same food, and, in all respects except housing, living like their neighbors; and give them other evidence as may be necessary to show that malaria is conveyed only by the mosquito.

[3] Classification of Howard, Dyar, and Knab.

Q. *How can you tell the Anopheles, malaria-bearing mosquitoes from the Culex and other kinds in the United States which do not convey malaria?*

A. One way is by their heads. *Anopheles* have straight bills and palpi nearly as long as their bills. The females of the other kinds have short palpi, except one kind which has a curved bill. The males of both *Culex* and *Anopheles* have long palpi, and one can not tell the species of the males in this way.

(a) Q. *Are there any other differences?*

A. The malarial mosquito is slight and graceful. The wings are generally spotted or dusky.

(a) Q. *Is there any other difference to note?*

A. Yes. The way of resting on a wall. *Anopheles* rest in a straight line, frequently standing on their head. The others rest "humped up." This is the only way that can be used to tell the live mosquito, and is the one usually used in practice.

(a) Q. *Can you tell something of the habits of the female Anopheles while feeding—on a person, I mean?*

A. She rarely bites in the daytime in the United States. The day mosquito of the South is *Aëdes* (*Stegomyia*) *ægypti*—the yellow-fever mosquito. *Anopheles* is shy and easily driven off, and will rarely bite one who is moving about; hence is most likely to bite one who is asleep. Her bite is less painful than that of other mosquitoes, and she does not sing so loudly. On this account, when mosquitoes are much complained of they are rarely *Anopheles*, and there can be many *Anopheles* about without much complaint.

Breeding of Mosquitoes

(a) Q. *Where do these mosquitoes breed?*

A. In water—in still water of ponds and pools and to some extent in the grassy edges of running water.

(a) Q. *How do these mosquitoes breed?*

A. They lay their eggs on the surface of the water. These eggs float, and in a few days hatch into larvæ, or "wiggle-tails." These larvæ live in the water, and in time turn to purpæ, or "tumblers," which turn into mosquitoes. There are four changes in the development of mosquitoes, just as for butterflies; the eggs for both; the larvæ in place of the caterpillars; the pupæ in place of the chrysalis, and the mosquitoes in place of the butterflies. For mosquitoes all these changes must take place in water, and for *Anopheles* it will take from 12 to 16 days in summer weather—longer in cool weather.

(a) Q. *Can one tell the larvæ of Anopheles?*

A. Yes. The *Anopheles* larva lies at the top of the water and *parallel* to it, for all the world like a basking pike. The larvæ of

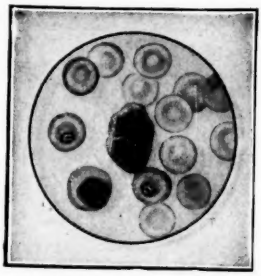

Fig. 1.—Normal red blood cells, and red blood cells containing malarial parasites.

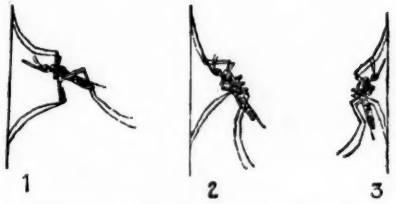

Fig. 3.—Resting posture of mosquitoes; 1 and 2 Anopheles; 3 Culex pipiens. (After Sambon.)

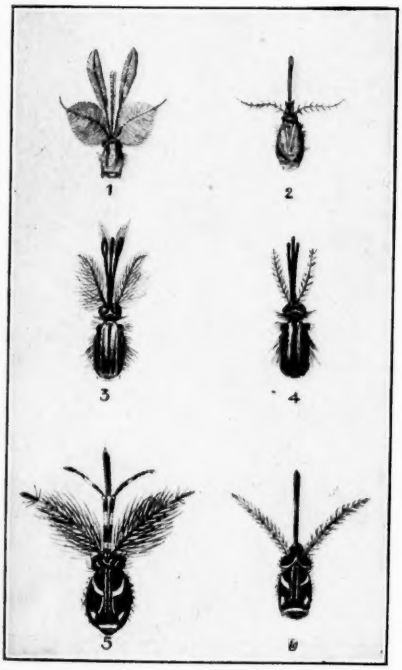

Fig. 2.—Heads of mosquitoes; 1 and 2 male and female Culex pipiens; 3 and 4 male and female Anopheles; 5 and 6 male and female Aëdes aegypti. (After Stitt.)

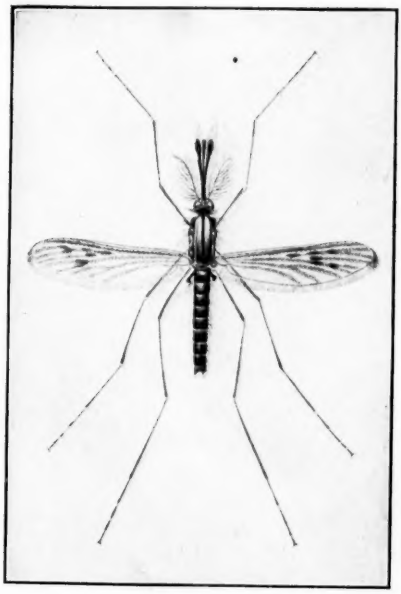

Fig. 4.—Anopheles maculipennis (quadrimaculatus), male. (After Castellani and Chalmers.)

Fig. 5.—Anopheles maculipennis (quadrimaculatus), female. (Castellani and Chalmers, after Austen.)

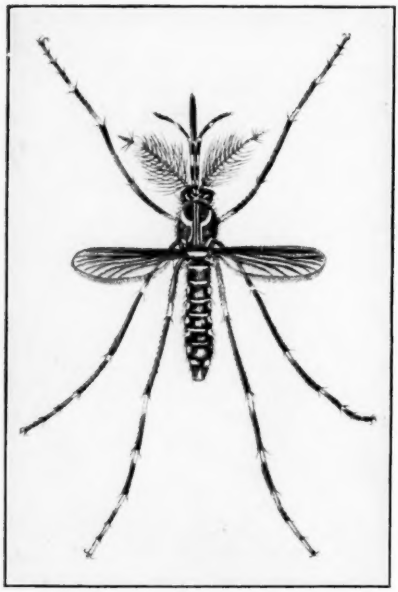

Fig. 6.—Aëdes aegypti, male.

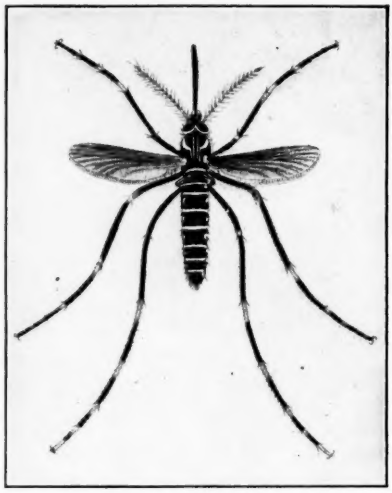

Fig. 7.—Aëdes aegypti, female.

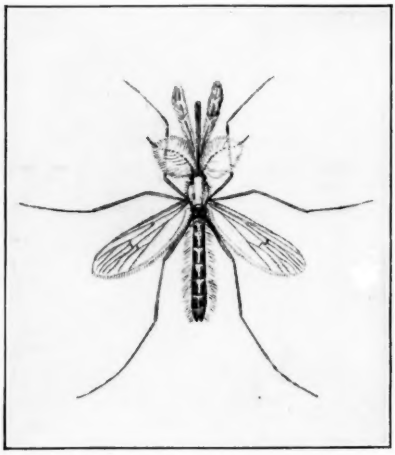

Fig. 8.—Culex, male. (After Howard.)

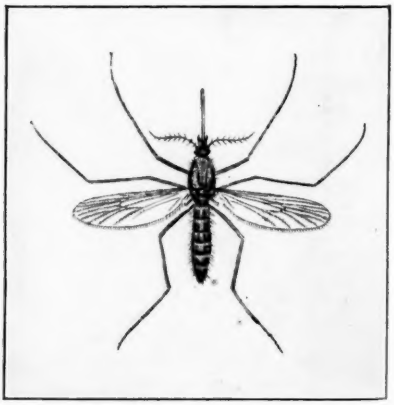

Fig. 9.—Culex, female. (After Howard.)

Fig. 10.—A raft of Culex ova. (After Deaderick.)

Fig. 11.—Patterns assumed by Anopheles ova. (After Deaderick.)

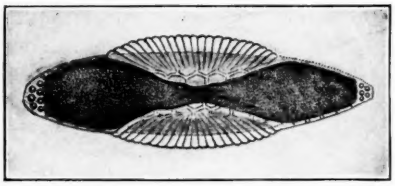

Fig. 12.—Egg, Anopheles maculipennis (quadrimaculatus). (After Ludlow.)

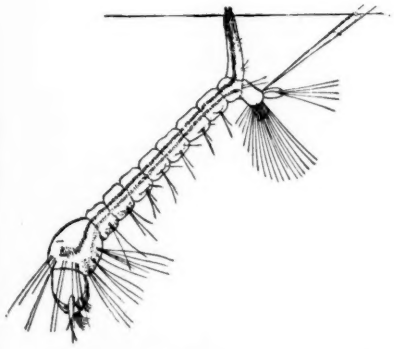

Fig. 13.—Larva of a Culex mosquito. (After Howard.)

Fig. 14.—Larva of Anopheles mosquito. (Castellani and Chalmers. Modified after Howard.)

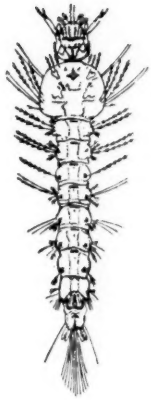

Fig. 15.—Larva of Anopheles maculipennis (quadrimaculatus). (Castellani and Chalmers, after Nuttall and Shipley.)

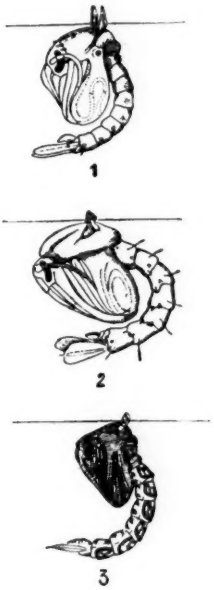

Fig. 16.—Pupae; 1 Culex: 2 Anopheles; 3 Aëdes aegypti. (After Howard.)

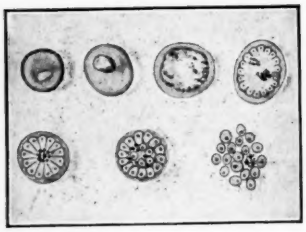

Fig. 17.—Parasites of tertian malaria. (After Thayer and Hewetson.)

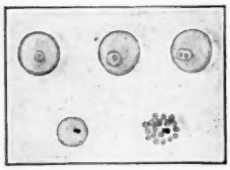

Fig. 18.—Parasites of estivo-autumnal malaria. (After Thayer and Hewetson.)

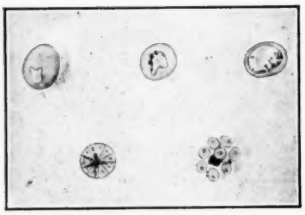

Fig. 19.—Parasites of quartan malaria. (After Thayer and Hewetson.)

Fig. 20.—Fertilized female malarial parasite (Zygote). (After Craig.)

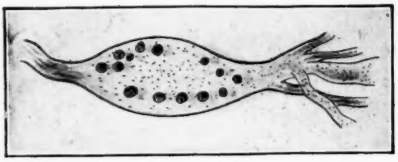

Fig. 21.—Stomach of mosquito with oöcysts. (After Craig.)

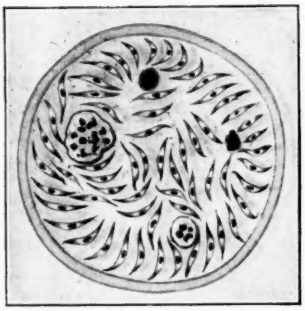

Fig. 22.—Sporozoites in oöcyst. (After Craig.)

Fig. 23.—Sporozoites. (After Craig.)

other mosquitoes hang from the top, head downward. If the latter are touched, they will always dive. If the *Anopheles* larva is touched, while it may dive it will generally "scoot" backwards along the top of the water. They are not a bit alike, and once seen no one will ever mistake one for the other.

Q. *Is it important to recognize the larvæ of Anopheles?*

A. Yes; it is far more important to recognize the larvæ of *Anopheles* than the mosquitoes themselves, because this enables us to find their breeding places and, hence, to destroy them.

(a) Q. *In what kind of places do Anopheles breed?*

A. They prefer to breed in *clean* water, in pools and ponds with grassy edges, or among floating leaves, water plants, or other floatage. A marshy piece of ground with many small pools, among bullrushes and sedge, is an ideal place. The grassy edges and quiet pools formed by obstruction on small streams are also favorite places, as are cattle tracks. Some species breed well in large ponds.

(a) Q. *Do they breed in such places only?*

A. They *occasionally* breed in almost any collection of water, unless it is very foul; shallow wells, water barrels, tin cans, etc., especially if they have leaves or grass in them or the green algæ—"frog moss." Generally, however, they avoid barrels, cans, and other artificial containers.

(a) Q. *How long must a pool last to breed Anopheles?*

A. Since it takes usually about 14 days for the egg to produce the mosquito, if a collection of water dries up completely in less than 14 days, it is not likely to breed *Anopheles* mosquitoes.

Malarial Parasites in Man

(a) Q. *When a mosquito injects malarial parasites into a person's blood, what becomes of them?*

A. The parasites which she injects enter the red blood cells. They are then extremely small. They grow by feeding on the blood cells and get bigger and bigger. Then their edges become scalloped (see picture). Then they divide into a number of wedge-shaped pieces, meeting in the middle something like the slices of a pie. Then the blood cells break up and set the young parasites free, and each one of them starts off as a new parasite on its own account and tries to enter another red blood cell and repeat the process of its mother parasite.

(a) Q. *Into how many parts does a parasite divide?*

A. Into from 8 to as many as 24 or 32, according to the kind, so they may increase very rapidly.

(b) Q. *Are there different kinds of parasites?*

A. Yes; there are at least three kinds, each of which produces a different form of malarial fever.

(b) Q. *How long does it take from the time the parasites enter a red blood cell until they divide into daughter parasites?*

A. It depends on the kind of parasite. One kind, the *tertian*, takes about 48 hours, or two days. Another, the *quartan*, 72 hours, or three days. A third, the *estivo-autumnal*, from about 24 to 48 hours. This last form is much less regular in its time than the other two. It produces the worst kinds of malarial fever.

(b) Q. *What causes the chill and fever of the man with malaria?*

A. When the infected red blood cells break up they liberate not only the bunch of daughter parasites, but a small amount of poison which the parasites have formed, and, when a large number of them do this at the same time, this causes the chill and fever of the sick person, which occur just after the cells break down. It has been estimated that at least 150,000,000 of parasites must divide at the same time to liberate enough poison to produce a chill—generally many times more than this.

(a) ? Q. *Do all parasites in the red blood cells divide into others, as your have described?*

A. No. Besides the sexless forms which divide and produce chills, there are two other forms of the malarial parasites in the blood cells. These are the male and female forms of the parasites. These do not seem to affect the health of the person in whose blood they exist, but it is by means of these that the mosquito becomes infected when she sucks them up.

(a) ? Q. *How does the mosquito become infected with malarial parasites?*

A. By biting a person who has these male and female parasites in his blood. If she sucks up both kinds—male and female—she may become infected.

(a) ? Q. *What takes place then?*

A. If the mosquito sucks up only sexless parasites with the blood she will not become infected, no matter how many she takes. If, however, the proper kind of mosquito takes up the male and female forms of the parasite, they join together in her stomach and pass into her stomach wall, where they grow. After some time the bodies thus formed break and set free many young parasites, some of which finally find their way to the mouth of the mosquito. There the parasites are mixed with her saliva and are injected into a person when she bites him; then they enter the blood cells and start their life all over again.

(a)? Q. *How long does thin change take?*

A. Usually about 11 days in the summer. It takes longer in cool weather than in hot.

(a)? Q. *Is the mosquito dangerous to man until this change is completed?*

A. No. Until the parasites reach her saliva the mosquito can not inject them into the person she bites. She is not dangerous, even if she has bitten a man with malarial fever, until the time necessary for this to happen has passed.

(a) Q. *Do the parasites growing in the mosquito make her sick, as they do a man in whom they grow?*

A. No. The mosquito seems to be as well as ever.

(a) Q. *How long after an Anopheles bites a malaria carrier before it can transmit malaria to other people it bites?*

A. From 12 to 16 days.

(a) Q. *How long after a person is bitten by an infected Anopheles before he has symptoms of malaria?*

A. From 6 to 15 days.

SECTION II.—PREVENTION OF MALARIA

(a) Q. *Can malarial fever be controlled or prevented?*

A. Yes.[4]

(a) Q. *What can be done to lessen or get rid of it?*

A. There are several methods which can be used.

First. By getting rid of the *Anopheles* mosquitoes which carry it.

Second. By not letting these mosquitoes get to well people to bite them.

Third. By so treating persons having malarial parasites in their blood that they will not infect the mosquitoes.

Fourth. By so protecting healthy people that even if they are bitten by infected mosquitoes they will not develop malarial fever.

First Method.—Getting Rid of Anopheles

(a) Q. *How do you get rid of Anopheles?*

A. By destroying their breeding places.

DESTRUCTION OF BREEDING PLACES

(a) Q. *How do you destroy their breeding places?*

A. In two ways:

(1) By draining or filling up the pools, marshes, etc., in which they breed.

(2) By applying oil or Paris green on such pools or ponds as we can not drain or fill.

(a) Q. *How does draining or filling up pools prevent breeding?*

A. By leaving no water in which they can breed.

(a) Q. *How does oiling the pools prevent breeding?*

A. It kills the larvæ.

(a) Q. *How often should oil or Paris green be applied?*

A. Once in 10 to 14 days, according to the weather, would be often enough, but it is best done once a week on the same day of the week, so that it will not be forgotten. Use enough oil (coal oil or kerosene) to form a layer all over the surface, so that you can see it.

(a) Q. *Can all pools be oiled advantageously?*

A. No. If there be much grass in the pool the oil will not form a layer all over it. If the pool be large, that is, a pond, the wind will

[4] The control of malarial fever is a very different problem from its elimination or getting completely rid of it. The methods of work necessary to do this are simple, but to carry them out may well be beyond the economic limit allowable. To control it, however, that is, to so lessen its amount that it does little injury in a community, is much oftener possible. It is at last a question of economics.

blow the oil over to one side so that the surface on the other side is not covered. On grassy pools oil can not be depended on.

(a) Q. *How much Paris green should be used?*

A. One pound of Paris green to an acre of breeding surface will kill all of the *Anopheles* larvæ.

(a) Q. *Will Paris green kill any other mosquito larvæ besides Anopheles?*

A. No. Paris green kills *Anopheles* only, because the larvæ of the other mosquitoes do not eat the Paris green. The *Anopheles* larvæ do eat it and it kills them.

(a) Q. *How do we apply Paris green to water?*

A. We mix the Paris green with any other dust, such as ordinary road dust, slaked lime, flour, etc., using 1 handful of Paris green to 100 handfuls of the ordinary dust. Walk on the side of the pond where the wind blows from you to the pond and toss the Paris green mixture into the wind. The wind will blow it across the pond and leave enough on the water to kill the *Anopheles* larvæ.

(a) Q. *Is there any other way to apply Paris green?*

A. Yes. When dusting small pools or narrow streams many people use the ordinary hand blower, such as farmers use in dusting plants. Over very large areas it has been spread from airplanes.

(a) Q. *Have Anopheles larvæ other enemies besides man?*

A. Yes. The "top minnows" that are so abundant in some of our small, sluggish streams eat large numbers of them. In places where these minnows can get at them, *Anopheles* larvæ are rarely found. Where there is grass floatage or brush in the water frequently the fish can not get to the larvæ. Big fish are of little value—indeed, do harm by eating the minnows.[5]

It has recently been shown that the tadpoles of certain toads are enemies of mosquito larvæ.

Second Method.—Preventing Access of Anopheles to Well People

(a) Q. *How do we prevent Anopheles mosquitoes from getting to healthy people to bite them?*

A. (1) By screening the house; (2) by mosquito bars.

(a) ? Q. *How should a house be screened against Anopheles?*

A. The screen should be No. 16 wire. All windows should be screened and all doors, if they are left open after dusk. All holes

[5] In this first method may also be noted the killing of *Anopheles* in dwelling houses. Sometimes after feeding at night *Anopheles* remain in the house, hiding in dark places. These are almost sure to again bite the people living in the house and are therefore much more dangerous than the same number out of doors. They may be killed with a "fly-swatter" or, if on the ceiling, by holding under them a small amount of coal oil in the top of a blacking box or yeast-powder can, into which they will drop. The can is to be nailed to the end of a long stick—a broom handle. Practice is required to find the mosquitoes. They look like little splinters on the wall and ceiling, but with practice this method can be made useful.

of all kinds by which mosquitoes can enter the house should be screened or closed, including the chimney. Screen doors should open outward. People should stay indoors after dusk, where mosquitoes can not reach them. *Anopheles* rarely enter a house in broad daylight.

(a) Q. *Will mosquitoes come down chimneys?*

A. Yes.

(a) Q. *How can mosquitoes be prevented from coming down chimneys?*

A. By covering the top of chimney with a piece of screen wire or by pasting paper over the fireplace so as to shut it entirely.

(a) Q. *Can mosquitoes be kept out of the chimney any other way?*

A. Yes. Hang a long, narrow wire cage containing about 100 moth balls in the chimney so that it is 2 feet below the top of the chimney. Mosquitoes do not fly down a chimney so protected.[6]

Third Method.—Preventing Infection of Mosquitoes

(a) ? Q. *How can we treat persons with malarial parasites in their blood so that they will not infect mosquitoes?*

A. In two ways; (1) By treating everyone who has these parasites in his blood until he is *cured* completely, not just partly well, to relapse later. This is the doctor's business. (2) By keeping these people in a screened house, or at least under a mosquito bar at night, as long as they have these parasites in their blood.

(a) ? Q. *Do people have parasites in their blood only when they show symptoms of malarial fever?*

A. No. A man may have parasites in his blood and be able to infect mosquitoes which bite him and yet show no signs of sickness. People are likely to have parasites in their blood for some time—days, weeks, or even months—after an attack of malarial fever.

(b) Q. *How do you explain that?*

A. (1) It takes a large number of parasites to make enough poison to produce fever, the number differing for different people, and one may have many parasites and yet not enough to produce fever. (2) The sexless parasites which divide are the only ones which produce fever, and there may be only a moderate number of these in one's blood and yet enough male and female forms to infect mosquitoes. These last, you know, are the only forms which do infect mosquitoes.

(b) Q. *What are the people called who are well and yet are able to infect mosquitoes.*

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[6] How to screen houses against mosquitoes may be found in Reprint No. 1153, from Public Health Reports, Apr. 22, 1927.

A. They are called "carriers," and spread malaria in a community just as a sick person does.[7]

(b) Q. *Is malarial fever likely to relapse?*

A. Yes. Untreated, or imperfectly treated, it is almost sure to relapse, and to relapse several or even many times. The infection frequently lasts over from one season to another, the person being well for months between the attacks. It has been known to relapse after two years' interval. Many of the attacks of fever in a malarial country are relapses and not new infections. All those that occur in the winter and up to June or July are probably relapses.

For summary, see diagram on the following page.

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[7] There seems to be a field for especially useful work in this method of prevention in the Temperate Zone among the "carriers" and people with latent malaria during the winter when there are no active *Anopheles*. This method has been utilized in Mississippi (by Bass) and in Georgia, and marked success reported. It had been previously used, and successfully, in several places in the Tropics, first by Koch at Stephansort.

It is, however, much more applicable to a temperate climate in which during the winter season there is no flight of *Anopheles*. If the "seed parasites" in the human carriers are destroyed during this season, the malaria parasite is eliminated from the community and malaria will, of course, disappear, unless introduced from elsewhere. The parasite has not been found to hibernate in the mosquito in middle Mississippi.

DIAGRAM SHOWING METHOD AND MEANS OF PREVENTING MALARIA

PREVENTION OF MALARIA

- **I. Getting rid of Anopheles**
  - (1) Destruction of breeding places
    - (*a*) Draining and filling
    - (*b*) Oiling or fouling
    - (*c*) Introducing fish
    - (*d*) Dusting Paris green
- **II. Preventing access of mosquitoes to well persons**
  - (1) Screening the house
  - (2) Mosquito bars
- **III. Preventing the infection of mosquitoes**
  - (1) Treating infected persons until completely cured of malarial infection
  - (2) Keeping such persons under mosquito bars and in screened houses
- **IV. Treating malaria cases**
  - (1) Use of quinine under the direction of a physician